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Interim Report
Technical Publication 29
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EXPERIMENTAL INPUT-DATA-HANDLING PROCEDURES FOR WEATHER OBSERVATIONS FROM THE FAA MESONETWORK

Keith D. Hage
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June 1963

Project 204-1

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ABSTRACT

A set of experimental computer programs designed to process high-frequency observations from the Federal Aviation Agency mesometeorological network at Atlantic City, N. J., is described in general terms for users who may require a reference to the scope, options, and limitations of the programs without complete detail. The description supplements but does not replace the program specifications and operating instructions. Three principal phases of the input-data-processing procedures are described in sequence. Phase 1 deals with conversion, unpacking, error-checking, and decoding methods and is outlined in the first sections. Phase 2 deals with the methods of ordering and summarizing the data. Phase 3 briefly discusses the data-merge routine and output formats. An example of unprocessed observations from the mesonetwork, together with the outputs of phases 1 and 2, is presented and discussed at the end of the report.

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1.0 INTRODUCTION

An automatic mesoscale meteorological data-observation and -communication system has been designed by the Federal Aviation Agency and installed at the National Aviation Facilities Experimental Center, Atlantic City, N.J. [1, 2, 3], primarily to support the Agency's air-traffic-control projects. This network can also provide data for the development of 1- to 2-hr terminal-forecast techniques. Certain important tasks, like error checking, decoding, arranging, and averaging, must be carried out before analysis and prediction techniques can be tested on the data. These tasks are commonly grouped under the label IDH or input-data handling. The initial family of computer programs prepared for the application of IDH functions to mesonetwork data is described in this report. Detailed specifications, tape descriptions, and operating instructions are contained in separate unpublished documents.

2.0 SCOPE AND OBJECTIVES

The development of IDH procedures was initiated before data were received from the mesonetwork. Although limited information was available on the properties and behavior of high-frequency observations of some of the variables, such information was inadequate for the final design of error-checking and averaging techniques. The initial set of computer programs is neither wholly automatic nor particularly efficient since a large measure of flexibility was desired. Therefore, experience with the output of the mesonetwork and with analyses of time and space variability of the parameters measured will provide the necessary background for substantial improvement in data-handling methods in the near future.

Since continuous visual monitoring of the raw data is not practical, it is necessary to check the readings for occurrence of instrument failure or malfunction, communication failure from individual transducers, punch stoppage, or garbled data. In the initial programs, subtle errors caused by instrumental drift, inadequate response, minor electrical noise, improper calibration, etc., are not considered. Three types of checks are included: minimum variation, maximum variation, and cross variation. The first of these identifies occurrences of unchanged readings over specified time intervals and is useful for isolating instrument or communication failure and for instrument malfunctions that result in constant values within a valid scale range. The second type identifies isolated large changes that occur between consecutive readings as a result of system noise, ceilometer-lamp failure, garbled data, etc. The third and final type of check involves cross checks between different variables at the same station or between one variable and specified input values that are supplied to the program. No cross checks between stations are included in the initial programs, although such checks may be necessary in the future as a partial solution to calibration-error problems.

Occurrences identifiable by means of one or more of the three types of error checks can be displayed as suspicious occurrences, without modification to the actual observations. Indeed, manual inspection or analysis of suspicious occurrences is necessary initially for the isolation of true errors. True errors can be modified or removed by punched-card entries to the data tape or by automatic identification and replacement in the computer. Experience with actual data shows that the manual phase can be eliminated gradually without significant program modification.

Individual readings are automatically converted to forms suitable for analysis, as required, and arranged as words in a message format. Complete sequences of messages are provided through the use of error or missing-message codes, which permit final output in either complete time-series or synoptic form.

The second phase of the IDH programs was designed to achieve maximum reduction in the volume of data with minimum loss of information that may be of importance in later analysis and prediction studies. For most variables, two consecutive data samples of equal but flexible length are used to provide both average (reference) values and a statistical measure of variations that occur during the sampling interval. If the reference values do not differ appreciably from the first subsample to the second, the whole sample

is used for computations; if, however, they do differ appreciably, the magnitude of the difference is used as a measure of variability. Prefix numbers are used to describe the nature of the time variations and the quality of the data in the subsample.

The third and final phase of the IDH system was designed to provide output formats suitable for meteorological and statistical analyses of the data. All reports can be extracted as a time series in the form: one station, all variables, sequential times, or as merged reports in the form: one variable, all stations, sequential times.

3.0 INPUT DATA

3.1 Input-data Format

At the data central, weather messages are received from each mesonetwork station and punched sequentially on 5-channel paper tape by individual BRPE punch machines. A spare punch is available to receive messages while any of the other punches is being reloaded.

TABLE 3-1
LONG-MESSAGE FORMAT

Item	No.* of characters	Possible range	Basic decimal unit
Figures code	1	Nil	-
Station identifier	2	00 to 99	-
Day	3	000 to 999	1.0 day
Hour	2	00 to 99	1.0 hr
Minute	2	00 to 99	1.0 min
Format identifier	1	0 to 9	-
Temperature	4	-999 to +999	0.1°C
Dew-point temperature	4	-999 to +999	0.1°C
East-west wind component †	3	-99 to +99	1.0 knot
North-south wind component ‡	3	-99 to +99	1.0 knot
Transmission	2	00 to 99	1.0%
Pressure	3	000 to 999	0.1 mb
Option 1	12	Optional	-
Rain count	1	0 to 9	0.01 in./12 sec
Rain-no rain indicator	1	+ or -	-
Option 2	5	Optional	-
Tangent of elevation angle 1	3	000 to 999	0.1
Tangent of elevation angle 2	3	000 to 999	0.1
Tangent of elevation angle 1	3	000 to 999	0.1
Tangent of elevation angle 2	3	000 to 999	0.1
Carriage return	1	Nil	-
Line feed	1	Nil	-

*Total number of characters, without options, is 46.
†East winds are positive.
‡North winds are positive.

TABLE 3-2
MESONETWORK PAPER-TAPE CODE

Channel						Character
1	2	F	3	4	5	
		•				
	X	•	X		X	0
X	X	•	X		X	1
X	X	•			X	2
X		•				3
	X	•		X		4
		•			X	5
X		•	X		X	6
X	X	•	X			7
	X	•	X			8
		•		X	X	9
		•	X			+
X	X	•				-
		•		X		Carriage return
	X	•				Line feed
X		•		X	X	Missing parity
X		•	X			Power failure
X	X	•		X	X	Figures code
		•				

The time between observations is 6 sec for cloud height and 12 sec for all other parameters. All observations taken within a 12-sec period are summarized in a single message every 12 sec. This is the long-message format, shown in Table 3-1. Alternatives to the long message are the abbreviated message and various combinations of long and abbreviated messages. Further observations or other types of information can be included under options 1 or 2 (Table 3-1). The remainder of this report is limited to a description of the processing of the basic long-message format without options.

This format requires no alphabetic characters. Two more special characters, for missing parity and power failure, are not shown in the table. Table 3-2 is a coding chart.

3.2 Conversion from Paper Tape to Magnetic Tape

In the initial configuration, conversion from paper tape to magnetic tape is accomplished on the IBM 7765. The data are written in binary mode on 7-track 200-bit/in. magnetic tape. Horizontal and vertical parity checks are carried out automatically. The data are packed and written in the form of one record per message with one or more end-of-file marks at the end of each station. The two characters "missing parity" and "power failure," shown in Table 3-2, and all possible 5-channel punch combinations not shown in Table 3-2 are converted to an error code.

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4.0 UNPACKING, DECODING, AND ERROR-CHECK ROUTINES (PHASE 1)

Following entry into the computer, the data are unpacked in core, and error checks are performed on message lengths and format codes. At this point, appropriate parts of the mesonetwork-message numeric code are converted to a numeric code that will be more useful in subsequent analysis. Error checks are performed on each item of each message, and an output tape is written in binary mode with 556-bit/in. density. The output tape contains 50 messages (10 min of data) per record, and has one end-of-file mark at the end of each hour and two end-of-file marks at the end of data from each station. Each message consists of 18 words. The first word contains information on errors in the message. The remaining 17 words contain the data in the order shown in Table 3-1. The optional and functional items in Table 3-1 are not included.

4.1 Message-format Error Check

During the unpacking routine, message items are separated into words in sequence, starting with the station number. If the format identifier (word 5) is verified as unity, unpacking proceeds through all meteorological variables. The sign character of signed items (Table 3-1) is checked, and the appropriate number of characters is assigned to the word. Three characters, preceding the carriage return indicator, are required for the last word of each message. If either the format identifier is incorrect or the number of characters in the last word is not three, the entire message is regarded as erroneous and is replaced with an error code. The error code appears as asterisks in the printout.

4.2 Station and Time Error Checks

Punched cards are used to specify station numbers, station sequence, initial message time, and all input parameters required for checking meteorological variables. A maximum of four consecutive erroneous station numbers preceding the end-of-file marks is permitted before the computations are halted. If the indicated time (day, hr, min) of the message that is being checked is more than 1 min later than the indicated time of the preceding message, it is assumed that from one to five messages are missing. Error codes are used to replace the missing message(s) until the requirement for 5 messages/ min is satisfied. This procedure is continued until five consecutive messages with the same time indicator (day, hr, min) are received. A similar procedure is followed if the indicated time of the message is at least 1 min earlier than the time of the preceding message. However, if more than four consecutive messages have times that are earlier than those of the preceding messages, all computations are halted.

4.3 Cross-variation Error Checks

Six criteria involving two variables in the same message or involving input limits are included in the program. For each of these except the last, the time and a coded representation of the error word are printed. Violations of the first and second criteria result in automatic replacement of the variable by an error code. The specific criteria are described below in the notation of Table 4-1. Coded representations of the error words are given in Table 4-2 (at the end of Section 4.7).

TABLE 4-1
SYMBOLS USED IN DESCRIBING ERROR CHECKS

Symbol	Definition
IP-n	Input punch card number n used to specify limits or averaging intervals
i	Subscript denoting sample time
$\bar{X}^j$	Average value of the parameter X over time interval j
T	Temperature, °C
T_d	Dew-point temperature, °C
P	Pressure, mb
TR	Transmission, %
TN	Tangent of the elevation angle of the ceilometer beam
CH	Cloud height, 10 ft
u	East-west component of wind speed, knots
v	North-south component of wind speed, knots
V	Resultant wind speed, knots
DD	Resultant wind direction, deg.
RC	Rain count or amount of rain, 0.01 in.
RNR	Occurrence or nonoccurrence of rain

<u>Forbidden values of rain count</u>.

Criterion: RC $\neq$ 0, 1, 2, 3, 4, 5.

Error word: NA FIG RC.

<u>Forbidden values of the rain-no rain indicator</u>.

Criterion: RNR $\neq$ +, -.

Error word: NA FIG RNR.

Low transmission in dry air.

Criterion: TR < IP-2 with $T - T_d \geq$ IP-3.

Error word: TRANS LOW.

High transmission in precipitation.

Criterion: TR > IP-5 with RC > IP-4.

Error word: TRANS HIGH.

Inconsistent rain count and rain-no rain indicator.

Criterion: RNR ≠ + with RC > 0.

Error word: NAG RNR RC.

Negative mean dew-point depression.

Criterion: $\overline{T}_d^j > \overline{T}^j$ (j = IP-12).

Error word: T-T(D) MEAN SP.

Experience with the actual network observations will be required before useful numerical values can be specified for IP-2 and IP-5.

4.4 Maximum-variation Error Check

Five variables are checked for occurrences of large changes between consecutive readings. The first four of these automatically result in replacement of the observation by an error code when the observation is apparently wrong, but the fifth results only in an identification of occurrence because the tolerance has not yet been adequately defined.

Excessive temperature change.

Criterion: $|T_i - T_{i-1}| >$ IP-9.

Error word: TEMP VAR.

Excessive dew-point temperature change.

Criterion: $|T_{di} - T_{di-1}| >$ IP-11.

Error word: ST T(D) VAR.

Excessive pressure change.

Criterion: $|p_i - p_{i-1}| >$ IP-13.

Error word: ST PRESS VAR.

Excessive transmission change.

Criterion: $|TR_i - TR_{i-1}| > $ IP-8.

Error word: TRANS VAR.

Excessive cloud-height change.

Criterion: $|\sum_j CH_i - \sum_j CH_{i-2}| > $ IP-6 $(j = 10 \text{ min})$.

Error word: CH TOTALS NOT WITHIN TOLERANCE.

Failure of a single lamp in the rotating-beam ceilometer will result in alternate true cloud-height readings and no cloud readings (coded as 999). The last item provides a method for the detection of such occurrences.

4.5 Minimum-variation Error Check

Two procedures are used for the detection of lengthy periods of unchanged readings. In one method, differences between consecutive mean values of the variable are computed and counted: in the other, consecutive occurrences of unchanged readings are counted and compared with specified tolerances.

No change in transmission.

Criterion: $|TR_i - TR_{i-1}| = 0$ for IP-10A occurrences.

Error word: NO TRANS VAR.

Wind speed doubtful.

Criterion: $V < 3$ for IP-10B occurrences.

Error word: CALM WIND.

No change in wind-speed components.

Criterion: $|u_i - u_{i-1}| = 0$ or $|v_i - v_{i-1}| = 0$ for IP-10C occurrences with $V \geq 3$.

Error word: WIND U OR V VAR.

No cloud, ceilometer malfunction, or forbidden digits.

Criterion: $CH_1 > 600$ and $CH_2 > 600$ for IP-10D occurrences.

Error word: NO CLD HT.

No change in cloud height.

Criterion: $|TN_i - TN_{i-1}| = 0$ for IP-10E occurrences with $TN_i \leq 600$ and $TN_{i-1} \leq 600$. All possible differences between consecutive groups of two tangent values are computed.

Error word: NO CLD HT VAR.

No change in resultant wind direction.

Criterion: $|DD_i - DD_{i-1}| = 0$ for IP-10F occurrences with $V \geq 1$.

Error word: WIND DIR VAR.

No change in mean temperature.

Criterion: $|\overline{T}^j_i - \overline{T}^j_{i-1}| > 0 \quad (j = \text{IP-12})$.

Error word: T MEAN VAR.

No change in mean dew-point temperature.

Criterion: $|\overline{T}^j_{di} - \overline{T}^j_{di-1}| > 0 \quad (j = \text{IP-12})$.

Error word: T(D) MEAN VAR.

No change in mean pressure.

Criterion: $|\overline{p}^j_i - \overline{p}^j_{i-1}| > 0 \quad (j = 10 \text{ min})$.

Error word: P MEAN VAR.

The first six items involve consecutive occurrences in excess of the number specified on input cards. The message time of the first occurrence, the error word prefaced by the phrase ERROR EXCEEDING TIME TOLERANCE, and the total number of occurrences are printed for each violation.

4.6 Decoding Procedures

The following conversions, scale factor multiplications, and tables are used to translate message numbers to forms that are suitable for analysis.

Temperature. The constant +250 is added to the appropriate message number to yield temperature in degrees centigrade.

Dew-point temperature. A table [5] is stored in the computer for direct conversion of the appropriate message number to dew-point temperature in degrees centigrade. The table is based on standard Foxboro dewcell conversion procedures. The conversion table provides resolution to within ±0.1°C.

Transmission. The appropriate message number is multiplied by 2 to yield transmission in percent.

Pressure. A table [5] is stored in the computer for direct conversion of the appropriate message number to sea-level pressure in millibars. Values in the table were derived from station elevations and assumed isothermal temperature profiles at the reported station temperature. The conversion table provides resolution to within ±0.2 mb.

Cloud-base height. Tangent values in each message are multiplied by 40 for conversion to cloud-base height in tens of feet. Resolution is a function of the angle of the ceilometer beam [2].

4.7 Output

The format of the output magnetic tapes from phase 1 was described at the beginning of Section 4.0. These tapes serve as input to the data-summary program (phase 2).

Printed indicators of errors or other occurrences detected by the criteria in Sections 4.1 through 4.6 can be obtained from the output tape. The indicators normally include the time of occurrence, the error identifier in abbreviated words or numeric form, and, in some instances, the entire message. At the end of the record of errors for each station, a summary of input parameters and the total number of occurrences of each error is provided. The coded representations of error words are given in Table 4-2. Combinations of errors in the same message are represented by addition of the appropriate numbers in Table 4-2.

TABLE 4-2
CODED REPRESENTATION
OF ERROR WORDS

Error word	Numeric code
ST PRESS VR	00000000001
TRANS LOW	00000000002
TRANS HIGH	00000000004
TEMP VAR	00000000200
NO FIG RC	00000010000
NO FIG RNR	00000020000
NA GR NR RC	00000040000
ST T(D) VAR	00002000000
TRANS VAR	00000000010

5.0 DATA-SUMMARY ROUTINES (PHASE 2)

The rapid cycling time used in the mesonetwork at Atlantic City was chosen partly for practical reasons, such as the rotation rate of the ceilometer beam, and partly because of the lack of adequate knowledge regarding the high-frequency time changes of some of the variables. The present configuration will permit experimentation with various sample sizes and with various techniques for representing the observations. Information on the operational requirements, on the characteristics of prediction techniques, and on the capabilities and limitations of the instruments should provide the necessary guidance for experimentation.

Against this background, an attempt has been made to provide a suitable set of computer programs for summarizing the meteorological data. For a prescribed sample size, a reference value and a measure of the magnitude of the time changes of each variable within the sample are computed on magnetic tape in both synoptic-map format and time-series format. Prefix notations are used to describe the quality of the data and the nature of the time variations.

5.1 Input-data Format

The time-series format consisting of all messages from a single station is retained in the data-summary program until the final output stage. All possible message times are occupied either by observations that have been passed by the error-check routine or by error codes. Because of time limitations, a procedure for the replacement of observations that are not automatically removed by the error checks has been temporarily eliminated in the initial programs. Replacements can be made, however, in the output tapes or in subsequent processing.

5.2 Data-summary Computations

A data sample comprising two equal nonoverlapping subsamples is used as the basis for computations of average (reference) values of cloud-base height, transmission, wind, pressure, temperature, and dew-point temperature. A total sample size of 2, 4, 10, or 20 min (no others) can be specified for each variable.

The quality of the data is examined by comparing the number of valid reports in each subsample with the total possible number. If more than half of the possible reports in each subsample are valid, the quality is considered acceptable and the reports are used for processing. Arithmetic means of valid reports are computed for each subsample of each variable except cloud height and precipitation. If the time change between mean values from consecutive subsamples exceeds specified tolerances, the change in mean value is used as a measure of variability. If the change is smaller than the tolerances, the standard deviation of the reports within the total sample is used as a measure of variability for temperature, transmission, and wind speed and direction. Numerical prefixes [5] are used to indicate both the quality of the data in each subsample and the nature of the time variations within the total sample. With appropriate specification of tolerances, the calculations of the sign and magnitude of the change in mean values within a data sample can be used for the

TABLE 5-1
INPUT PARAMETERS FOR PHASE 2

Input-parameter number	Description
IP-1	Number of observations in each subsample of cloud-base height
IP-2	Maximum median cloud height for computation of modal cloud height
IP-3	Minimum group size for computation of modal cloud height
IP-4	Number of observations in each subsample of transmission
IP-5	Minimum change between consecutive mean values required for a significant feature in transmission
IP-6	Number of observations in each subsample of wind velocity
IP-7	Minimum change between consecutive mean values required for a significant feature in wind speed
IP-8	Minimum change between consecutive mean values required for a significant feature in wind direction
IP-9	Number of observations in each subsample of temperature
IP-10	Minimum change between consecutive mean values required for a significant feature in temperature
IP-11	Number of observations in each subsample of dew-point temperature
IP-12	Minimum change between consecutive mean values required for a significant feature in dew-point temperature
IP-13	Number of observations in each subsample of pressure
IP-14	Minimum change between consecutive mean values required for a significant feature in pressure
IP-15	Number of observations in each subsample of rain-no rain indications
IP-16	Number of observations in each total sample of rain counts; IP-16 = 2(IP-15)

automatic identification of discontinuities or other significant features in the local time variations of each variable.

Similar procedures are used for the reduction of cloud-base height data except that median or modal values are used in place of arithmetic means, and the 10-percentile limits are used in place of standard deviations. Previous studies of high-frequency cloud-base height observations [4] provide some evidence that the frequency distributions of low cloud heights are systematically skewed in the sense that modal values are lower than either the mean or median values. For this reason, modal values are computed as references for cloud bases below 1000 ft (optional) in the data-summary program. Considerable experience with data from the twin-peak signal-detector circuits used on the mesonetwork rotating-beam ceilometers will be required before satisfactory automatic procedures for the definition of multiple cloud layers can be programmed.

Identical sample sizes are used for rain-no rain indications and for rain counts from the tipping-bucket instrument. For these parameters, the quality of reports with each sample is indicated by prefix notation together with the rain count and a crude measure of the continuity of precipitation.

Limits and other criteria that must be specified by punched-card entries into the data-summary tapes are listed in Table 5-1.

5.3 Output

The time-series output of phase 2 is written on magnetic tape in the form of nine records per file with a file content of 50 messages. Each record contains the centered time followed by prefixes, means, and measures of variability for tempterature, dew-point temperature, winds, transmission, pressure, precipitation, first cloud height, and second cloud height–in that order. The total output for one station is completed before the next station is started.

The synoptic-map-format output of phase 2 is written in binary mode at a density of 556 bits/in. Each tape contains a multiple of seven files. The files are temperature, dew-point temperature, transmission, pressure, wind, cloud height, and precipitation. In each file, a record contains in sequence the word count, parameter identification, time, station number, multiple parameters, second station number, etc. A storage capacity equivalent to 24 hr of single-station data is reserved for input. As a result, the quantity of data that is written on tape at one operation for multiple stations is a function of the number of stations.

6.0 EXAMPLE

Printed weather reports from mesonetwork station 1 for the period 2305–2325, 11 Feb. 1963 (day 42) are shown in Fig. 6-1. These data, in the message format shown in Table 3-1, were printed directly from the magnetic tape written by the paper-tape-to-magnetic-tape converter. The output of phase-1 error-check routines for the same time period is shown in Fig. 6-2. The summary of errors for the entire data sample on 11–13 Feb., together with the specified input tolerances, is shown in Fig. 6-3.

The top statement in Fig. 6-2 refers to the period of missing data in Fig. 6-1 from 2306 to 2318. Note that the message for 2318 was not accepted because only one report was received and the exact reference time was unknown. The error word ST T(D) VAR (Section 4.4) refers to changes in excess of 1.2°C (see tolerance IP-11 in Fig. 6-3) between consecutive dew-point temperatures. In each instance, the coded representation of the error word (Table 4-2) and the report number are included with the complete message. Note that the dew-point temperature has been replaced by an error word. The garbled first time digit in report no. 4 of minute 2319 (Fig. 6-1) resulted in the statement that time decreased (Fig. 6-2). The entire message was rejected because of the uncertainty in time. The statement ERROR EXCEEDING TIME TOLERANCE IN NO CEILING VAR refers to nonconformity with the fifth error-check criterion described in Section 4.5. According to the tolerances in Fig. 6-3 (IP-10E = 10), 10 consecutive unchanged tangent values are required to establish nonconformity. No automatic data changes were made as a result of this check.

The final error word ST PRESS VAR in Fig. 6-2 refers to the occurrence of a pressure change in excess of 1.5 mb (see tolerance IP-13 in Fig. 6-3) in report no. 4 of minute 2325. The processing illustrated in Figs. 6-1 through 6-3 was experimental, and the tolerances cannot be rigorously defended.

An example of the time-series output of phase 2 is shown in Fig. 6-4. The subsample size was 2 min (20 cloud-height reports, 10 reports for all other variables). The centered times of the total samples were 2318 and 2320, respectively. These times are in octal mode in Fig. 6-4. The centered time denotes the time of the first report in the last half of the total sample and is, therefore, 6 sec later than the true centered time. In this example, centered time 2318 refers to a total sample based on reports from minutes 2316 through 2319—except for the second cloud-height mean value, which is based on the last 2 min only. The columns headed PREFIX, MEAN, and VARIABILITY identify items that have been discussed in previous sections. The special columns are used for the direction and speed of the maximum wind in the sample and for the rain count and rain-no rain indicators. The resultant wind speed and direction are printed in the final columns on the right in Fig. 6-4. Prefixes 0 in the first data summary in Fig. 6-4 (time 2318) indicate that at least half of the reports in both subsamples were missing or erroneous. In the second summary (time 2320), the prefixes are 1 for all but cloud height. The prefix 1 indicates that at least half of the reports in the first subsample were missing or erroneous but more than half of the reports in the second subsample were accepted. The number 6 under the second special column for precipitation indicates that the first subsample was missing or erroneous and that no pre-

```
( 1 4223 51-198123 1  4159  - 1  42 36999•
( 1 4223 51-19911  1-  4159  -  9 42 35999•
( 1 4223 51-1991 1 1-  41581 -  8 4  4 999•
( 1 4223 51-1981 7-  -  4259  -  9 4   6 4 •
( 1 4223 51-19811  1-  4159  - 4 999  9 36•
( 1 4223 61-198119 1-  4159  -  9 42 36999•
( 1 4223 61-198112 1  41581 - 42999 36999•
( 1 4223 61-1991 5 1-  41582 -  9 42 36999•
1-2 2135    41586 - 48999 44999•
( 1 4223181-2 213     41581 - 48999 44999•
( 1 4223191-2  135-  -  4258  - 48999 44999•
( 1 4223191-2 4133-  -  42584 - 46999 42999•
( 1 4223191-2 2115-    41589 - 32999 42999•
( 1 42(3191-2  135-  -  42582 - 46999 44999•
( 1 4223191-2 4133-    42589 - 46999 44999•
( 1 42232 1-2 4134  -  42589 - 46999 44999•
( 1 42232 1-199128-    42587 - 46999 19 44•
( 1 42232 1-2 4132-  -  42588 - 14 46 44999•
( 1 42232 1-2 1122-    41589 - 48999 44999•
( 1 42232 1-2 213     4258  - 48999 44999•
( 1 4223211-2 2131-  -  4258  - 48999 44999•
( 1 4223211-2 2132-  -  42582 - 48999 46999•
( 1 4223211-2 2134-  -  42587 - 48999 46999•
( 1 4223211-2  132-    42589 - 48999 46999•
( 1 4223211-2 2135    42589 - 48999 16 33•
( 1 4223221-2 2135-    42589 - 48999 16 46•
( 1 4223221-2 2131  -  42585 - 48999 48999•
( 1 4223221-2 1129-  -  42581 - 48999 2  48•
( 1 4223221-2 2139-    42581 - 6 999 5 999•
( 1 4223221-2 5135-    42584 - 36999 56999•
( 1 4223231-2 2122-    4258  - 6 999 56999•
( 1 4223231-2 2132-  -  42585 - 6 999 58999•
( 1 4223231-2 2117-  -  42586 - 21 6  58999•
( 1 4223231-2 2126-  -  42579 - 6 999 23 58•
( 1 4223231-2 213  1  41587 - 6 999 22 58•
( 1 4223241-2 2133-    41585 - 6 999 58999•
( 1 4223241-2 3269 1  41586 - 6 999 56999•
( 1 4223241-2 21 6-    42586 - 6 999 56999•
( 1 4223241-2 213 -  -  42582 - 6 999 18 56•
( 1 4223241-2 2134-  -  42579 - 58999 21 31•
( 1 4223251-2 212  1 142586 - 58999 2  48•
( 1 4223251-2 4119 1 142583 - 58999 19 46•
( 1 4223251-2 4131 1 142586 - 56999 46999•
( 1 4223251-2 2119 1  41987 - 56999 46999•
( 1 4223251-2 2128 1 141584 - 52999 48999•
( 1 4223261-2 4127-    41586 - 48999 14 48•
( 1 4223261-2 4139 1 141584 - 48999 48999•
( 1 4223261-2 2134 1  41585 - 5 999 48999•
( 1 4223261-2 2135-  -  41587 - 5 999 48999•
( 1 4223261-2  126 1  41579 - 5 999 48999•
( 1 4223271-2 2131-  -  41587 - 52999 48999•
( 1 4223271-2 4133-  -  4158  - 22 52 48999•
( 1 4223271-2 2133-  -  41579 - 5 999 21 48•
( 1 4223271-2 5135 1  41579 - 5 999 48999•
( 1 4223271-2 1132 2 141579 - 5 999 48999•
( 1 4223281-2 1118-  -  4158  - 52999 48999•
( 1 4223281-2 4135 2 141581 - 54999 48999•
( 1 4223281-2 4139 1  41586 - 56999 48999•
( 1 4223281-2 2135-  -  41587 - 31 56 48999•
( 1 4223281-2 214  1  41585 - 56999 48999•
```

Fig. 6-1. Weather reports from mesonetwork station 1 for 2305–2325, 11 Feb. 1963.

```
TIME HAS INCREASED FROM   42  23   6 TO  42  23  19


ST T(D) VAR
   000002000000      REPORT NO. 1

00002000000     1   42    23    19    1   50*******   -0   -0   84 10080    0   -0   48  999   44  999


ST T(D) VAR
   000002000000      REPORT NO. 3

00002000000     1   42    23    19    3   48*******   -0    0   82 10089    0   -0   52  999   42  999



TIME HAS DECREASED
   000000000002     1   42    23    19    3   48*******    0    0   82 10089    0    0  128 3996  168 3996
   000000000002     1   42     0    19    1   50     24    0    0   84 10082    0    0   46  999   44  999

 1 MISSING REPORTS AT   42  23  19

ERROR EXCEEDING TIME TOLERANCE IN NO CEILING VAR   11CONSECUTIVE REPORTS. START TIME   42  23  19

ERROR EXCEEDING TIME TOLERANCE IN NO CEILING VAR   13CONSECUTIVE REPORTS. START TIME   42  23  20

ERROR EXCEEDING TIME TOLERANCE IN NO CEILING VAR   10CONSECUTIVE REPORTS. START TIME   42  23  22
ST T(D) VAR
   000002000000      REPORT NO. 2

00002000000     1   42    23    24    2   47*******    1    0   82 10086    0   -0   60  999   56  999


ST T(D) VAR
   000002000000      REPORT NO. 4

00002000000     1   42    23    24    4   48*******   -0   -0   84 10082    0   -0   60  999   18   56


ST PRESS VR
   000000000001      REPORT NO. 4
```

Fig. 6-2. Output of phase 1 for mesonetwork station 1 for 2305–2325, 11 Feb. 1963.

ERROR I. D.	TOTAL ERROR COUNT	PERCENT ERROR/
ST PRESS VAR	31.	0.31
TRANS LOW	0.	0.
TRANS HIGH	1.	0.01
TRAN VAR	2.	0.02
NC TRAN VAR	7141.	71.77
CALM WIND	1987.	19.97
WIND U OR V VAR	2668.	26.81
TEMP VAR	140.	1.41
NC CLD HT.	1836.	9.23
NO CLD HT. VAR	10729.	53.91
NA FIG RC	0.	0.
NA FIG RNR	0.	0.
NA GR NR RC	31.	0.31
ST T(D) VAR	721.	7.25
T-T(D) MEAN SP	0.	0.
T MEAN VAR	2.	0.02
T(D) MEAN VAR	3.	0.03
P MEAN VAR	0.	0.

TOLERANCES ARE

2	3	4	5	6	8	9	10A	10B	10C	10D	10E	11	12	13
5	50	0	98	28528	16	12	25	10	15	10	10	12	25	15

375. MISSING REPORTS FOR 3.77 PERCENT.

Fig. 6-3. Summary of the output of phase 1 for mesonetwork station 1 for 11–13 Feb. 1963.

CENTERED TIME (PACKED) 000000522722

VARIABLE	PREFIX 1	PREFIX 2	MEAN	MEAN	VARIABILITY	VARIABILITY	SPECIAL	SPECIAL		
TEMP	0		******		******					
DEW PT	0		******		******					
WIND	0	0	******	******	******	******	******	******	******	******
TRAN	0		******		******					
PRESS	0		******		******					
PRECIP							-0.	0		
CEIL. 1	0	0	******		******					
CEIL. 2			******							

CENTERED TIME (PACKED) 000000522724

VARIABLE	PREFIX 1	PREFIX 2	MEAN	MEAN	VARIABILITY	VARIABILITY	SPECIAL	SPECIAL		
TEMP	1		48.20		1.47					
DEW PT	1		20.60		******					
WIND	1	1	0.	-0.	0.	0.	0.	0.	0.	0.
TRAN	1		83.80		0.60					
PRESS	1		10086.00		******					
PRECIP							-0.	6		
CEIL. 1	0	3	184.00		76.00					
CEIL. 2			176.00							

Fig. 6-4. Data summary from the time-series output of phase 2 for 2316–2321, 11 Feb. 1963.

cipitation was reported on all remaining valid observations. Tables for the interpretation of prefix and special codes are provided in the program specifications. Decimal points for temperature, dew-point temperature, and pressure are misplaced one position to the right in Fig. 6-4. No measures of variability were computed for dew-point temperature and pressure because the problem of short-range aviation-terminal weather prediction does not immediately or specifically require them.

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8.0 REFERENCES

1. Datex Corp., Instruction Manual, Remote Station, Meteorological Data Recording System, 38 pp. 13,718 and 13,933, Federal Aviation Agency, Feb. 1962.

2. Federal Aviation Agency, NAFEC, Meso-Meteorological Network Description, 22 pp. Oct 1962.

3. Hilst, G. R., G. F. Collins, and E. Kessler, III, Recommendations for the Initial Mesonetwork Station and Configuration, FAA NAFEC Site, 12 pp. Tech. Memo. 9, Contract FAA/BRD-363, The Travelers Research Center, Inc., Nov. 1961.

4. The Travelers Research Center, Inc., Aviation Terminal Weather Prediction, 250 pp. Final Rpt., U.S. Weather Bureau Contract Cwb 10041, Apr. 1962.

5. —, Computer Program Specifications for Experimental Input-Data-Handling Procedures for Weather Observations from the FAA Mesonetwork (Phase 1 and Phase 2). (Undated.)